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Education and Training

Graduate Program in Medical Informatics at the University of Utah

Abstract: The graduate student program in medical informatics at the University of Utah described in this paper comprises a Master of Science degree (since 1976) and a Ph.D. degree (since 1962). The average program length is 2 years for M.Sc. and 3-5 years for Ph.D. The aims of the program are to prepare graduates for careers in medical informatics in academic, hospital or industrial settings. There are several different courses of study, or tracks, within the department ranging from Expert Systems, Genetic Epidemiology, Health Care Quality, Hospital Information Systems, Medical Imaging, Medical Physics, to an intensive one-year M.Sc. degree course for physicians. After the first three quarters the students are required to take a qualifying examination in which they qualify for a Masters or Ph.D. degree. The program covers the total spectrum of medical informatics. About 10 students are admitted each year. There are 14 full-time faculty and 9 adjunct faculty. The total number of graduates is 151.

Keywords: Medical Informatics, Graduate Program, Education, Training

1. Introduction

Approaches to education in medical informatics at the University of Utah are based on 16 years of experience with a Master of Science degree program and about 30 years of experience with a Ph.D. program.

2. Curriculum Characteristics

The curriculum is offered by the University of Utah, School of Medicine, Department of Medical Informatics. In 1962, students were first admitted for a degree program.Major curriculum revisions occur ev ery 3 or 4 years. The program has been formally accredited by the Board of Regents for the University of Utah. The degree/qualification awarded are *Master of Science (M.Sc.)* since 1976, and *Doctor of Philosophy (Ph.D.)* since 1964. The program duration for Ph.D. is 3-5 years and for M.Sc. about 2 years. The department consists of 14 full-time faculty and 9 adjunct faculty, located at the University of Utah Health Sciences Center, LDS Hospital, Primary Children's Medical Center and Research Park.

Program Philosophy, Objectives and Focus

Aims:

The aims are to prepare graduates for careers in medical informatics in academic, hospital or industrial settings.

Department focus:

Research efforts of the department concern computer applications in medicine, genetics and physiology. There are eight primary areas of focus:

- Automated medical decision-making,
- Medical knowledge engineering,

- Hospital information systems/clinical data collection,
- Development of a unified medical language and text interpretation,
- Genetic epidemiology,
- Image analysis and biological signal processing,
- Mathematical modeling of physiological systems,
- Simulation as a tool for medical education.

Health Care environment:

Students are trained in a hospital and academic setting in which research projects are in many cases carried to the point of becoming a regular service to the hospital or school. Some projects result in new commercial products. Upon graduation students are employed in academic, hospital or industrial professions.

Department Tracks:

There are several different courses of study, or tracks, within the department. They are described in the Appendix.

Expert Systems:

This track emphasizes the application of techniques from expert systems research and artificial intelligence to problems in medicine. The student will have access to expert systems implementations on stand-alone workstations and on mainframe computers. Tools supporting both symbolic and mathematical techniques are used. Emphasis is on developing practical tools that enhance the delivery of medical care and contribute to the objectives of medical education.

- Genetic Epidemiology: Study focuses on genes which predispose to cancer. Advanced statistical methods are used with molecular data to map, isolate, and analyze these genes.
- Health Care Quality Track: This emphasizes the application of expert systems and interactive learning modalities to facilitate institutional quality management, and to maintain professional competence in the health care field. The student learns computer applications related to basic principles of: (a) quality management, including assessing and improving the effectiveness and efficiency of care; and (b) science information management, including identification of information needs, and retrieval and application of information to enhance the benefits of care. Emphasis is on developing practical computer means to identify priority areas for quality improvement, as well as use of informatics technology for continuing self-education to enhance clinical diagnostic and therapeutic performance.
- Hospital Information Systems: This track is designed to give the student a clear understanding of the requirements, concepts, and methods in analyzing and developing hospital information systems (HIS). Emphasis is on the clinical components of such systems and their integration into the traditional administrative and financial aspects of a HIS. Students are given both course work and practical project experience in working with a HIS. The HELP system at LDS Hospital is used as a laboratory where students can both study and develop applications for a HIS.
- Medical Imaging: The track emphasizes the applications of information processing in medical imaging. Students participate in the Medical Imaging Research Lab (MIRL) with students and faculty from several other departments. Research areas currently include digital X-ray imaging, magnetic resonance, and optical microscopy.
- Medical Physics: This emphasizes physiology, mathematical modeling, and instrumentation with a focus on the development of non-invasive methods for obtaining physiological data. Students are introduced to the value of various types of data in clinical management of critically ill patients. Research areas include instrumentation development as well as clinical research studies directed toward evaluation of potential improvements in management provided by new measurement modalities.
- One Year M.Sc. Degree for Physicians: This intensive one-year course is designed to give MDs the background and knowledge in medical informatics to have a working knowledge of clinical computing. A thesis research project in the field furthers the student's ability to perform an experiment and typically evaluate a clinical application of computing.

Program Structure

The program comprises four quarters. There is no evening or off-campus location where classes are taught. There is no practicum as such, and the curriculum is heavily oriented toward research work. During the first year the student is required to take a series of courses taught within the department. These courses are designed to provide a broad, comprehensive background in medical informatics. For a listing of courses that are offered, see the Appendix. After the first three quarters the students are required to take a qualifying examination in which they qualify to pursue a Masters or Ph.D. degree. Each student then chooses a track which provides the optimal background for the subject he/she chooses as the thesis topic.

Program Technology

The students in the program at Utah work with a variety of hardware and software products depending upon their chosen field of research. Those working at the LDS Hospital work with a large ten-processor Tandem

vstem that runs the big HELP hospital information system. (The HELP system network also includes several hundred PCs and minicomputers.) At the University, the Macintosh is the primary tool for the development of the Iliad program and the knowledge engineering activities that take place. At both these locations and at the Research Park facility where the Genetic Epidemiology division resides, students work with UNIX-based machines. A broad range of software tools is available, and the students become quite familiar with a number of programming languages.

Enrollment/Admission Intake, Application Requirements

Eight to ten students are admitted per year, many of whom are women (varies). Start is in the autumn quarter only. Entrance requirements are:

- One year of integral and differential calculus,
- two years of college level science,
- one course or equivalent experience in any programming language,
- undergraduate degree with a grade point of 3.3 or better (B+ average),
- three letters of recommendation from people who know the academic capabilities of the applicant,
- a letter from the applicant stating background and career interests,
- Graduate Record Examination (GRE) or MCAT test scores averaging at least 60%,
- a TOEFL score of 600 or better for foreign students,
- interview, in person or by telephone.

Graduates

The total number of graduates is 151 (M.Sc.: 82, Ph.D.: 69, male: 124, female: 27). Their occupations cover a wide range.

Examples for occupations of M.Sc. graduates are: Associate Director of Clinical Research, Systems Engineer, (Medical Systems) Programmer, Systems Analyst, Senior Biomedical Engineer, Regional Data Manager, Research Assistant in Genetic Epidemiology, Resident in Anesthesiology, NMR Scientist, Product Manager for Health Care Systems, Quality/Technology Resources Manager, Director of Business in Operations for Messaging Systems, and Practicing Pathologist.

Examples for occupations of Ph.D. graduates are: MRI Engineer, Program in Health Services Manager, Assistant Professor of Internal Medicine, Professor of Medical Informatics, Assistant Professor of Information Systems, Associate Professor of Computer Science, Medical Physics Researcher, Software Engineer, Applications Manager for Health Information Systems, Imaging Specialist, Director of Cochlear Implant Lab, Biomedical Engineer, Director Clinical Information Systems, and Patent Agent.

Types of Occupations Students Hold

Academic faculty, industry, programming, starting their own companies, etc.

3. Discussion

The graduate student program in medical informatics at the University of Utah described in this paper comprising a Master of Science degree and a Ph.D. degree has been shown to be successful with respect to the number and the careers of the graduates in academic, hospital or industrial settings. This is due to a program which has been reviewed and modified every 3 or 4 years and covers the total spectrum of medical informatics.

Appendix

Required Courses (MDINF: Medical Informatics)

-Fall quarter
MDINF 651 Hospital Information Systems (3 units),
MDINF 620 Medical Decision Making (3 units),
Physiology 520 or Human Genetics 501.
-Winter quarter
MDINF 631 Medicine for Engineers and Scientists (3 units),
MDINF 652 Biomedical Experimental Design (3 units),
MDINF 702 Knowledge Engineering (3 units),
(may be taken winter or spring quarter).
(MDINF 620 is a prerequisite).
-Spring quarter
MDINF 653 Biomedical Experimental Design (4 units).

-All quarters
MDINF 771* Graduate Seminar (l unit),
MDINF 670 Journal Club (all Ph.D. students) (1 unit).

Departmental Course Offerings

Hrs	Class	CLASS
3	501	Survey of Computers in Medicine,
3	620*	Medical Decision Making,
3	630	Mathematical Modeling of Physiological Systems,
3	631*	Medicine for Engineers & Scientists,
3	641	Applications of Physics in Medicine,
3	642	Applications of Physics in Medicine,
2	643	Genetic Epidemiology,
2	644	Genetic Epidemiology,
3	651*	Hospital Information Systems,
3	652*	Biomedical Experimental Design,
4	653*	Biomedical Experimental Design,
1	695**	Journal Club,
3	702*	Introduction to Knowledge Engineering,
1	771*	Graduate Seminar.

* Required Courses for all M.Sc. and Ph.D. students.
** Required Courses for all Ph.D. students.

Recommended Courses From Other Departments

(CPSC: Computer Science; FPMD: Family and Preventive Medicine; MATH: Mathematics; BIOL: Biology; BIOEN: Bioengineering; ELEN: Electrical Engineering; PHYSL: Physiology; ECON: Economics)

CP SC 501	Programming Language Concepts I,
CP SC 502	Programming Language Concepts II,
CP SC 503	Knowledge-based Programming,
CP SC 537	Introduction to Computer Vision,
CP SC 538	Advanced Computer Vision,
CP SC 546	Lisp and AI Programming,
CP SC 547	Artificial Intelligence,
CP SC 548	Expert Systems,
CP SC 553	Data Base Systems,
CP SC 567	Digital Signal Processing,
CP SC 651,2	Computer Graphics,
FP MD 640	Health Care Organization,
FP MD 710	Biostatistics,
FP MD 711	Statistical Methods in Epidemiology,
FP MD 713	Advanced Biostatistics,
FP MD 749	Study Design for Research and Evaluation,
MATH 504,5	Applied Stochastic Processes,
MATH 507	Introduction to Probability,
MATH 508,9	Statistical Inference,
MATH 5 11, 12, 13	Mathematical Biology,
MATH 607,8,9	Mathematics Statistics,
BIOL 501	Modern Human Genetics,

BIOL 545	Molecular Biology and Genetic Engineering,
BIOL 551	Population and Quantitative Genetics,
BIOEN 501	Analog Bioinstrumentation,
BIOEN 502	Digital Bioinstrumentation,
BIOEN 505	Ultrasound Bioinstrumentation,
BIOEN 551	Physics of X-ray and Ultrasound Radiology,
BIOEN 552	Physics of Nuclear Medical and Magnetic Resonance,
BIOEN 601	Microprocessor-based Bioinstrumentation,
BIOEN 640	Quantitative Physiology,
BIOEN 651	Advanced Topics in Magnetic Resonance Imaging,
BIOEN 652	Reconstruction Techniques in Medical Imaging,
BIOEN 655	Simulation and Modeling of Physiological Systems,
BIOEN 704	Diffusion in Pharmaceutical Systems,
EL EN 320*	Signals and Systems,
EL EN 620	Advanced Digital Signal Processing,
EL EN 624,5	Neural Networks,
EL EN 633,5	Fourier Optics,
PHYSL 603	Medical Physiology,
ECON 519	The Economics of Health.

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